REMARKS

Claims 1-18 and 30-41 were rejected under 35 U.S.C. 103(a) as unpatentable over Wijarankula in view of Graef or Tamatsuka. Claims 19-29 were rejected under 35 U.S.C. 103(a) as unpatentable over Wijarankula in view of Graef or Tamatsuka and further in view of Hakomori.

These rejections will be addressed with reference to the attached drawings (figures 1-10). The figures are made with the horizontal axis of nitrogen concentration and the vertical axis of oxygen concentration similar to Fig. 4 in the application, with further support throughout the specification.

Claims 30 and 31

In the claims 30 and 31, the recited epitaxial silicon wafer has a substrate, in which the nitrogen and oxygen concentration range is on or left side of the solid line (1st straight line) and the nitrogen concentration is equal to or more than 1×10^{13} atoms/cm^3 and the oxygen concentration is above a straight line of 9×10^{17} atoms/cm^3 oxygen concentration in figure 1 (attached).

Wijarankula discloses that the epitaxial layer without any defects may be obtained by controlling oxygen concentration in the substance after oxygen concentration and heat treatment in the silicon substrate before the epitaxial growth. However, nitrogen doping, which is a very important element of the present invention, is not suggested at all, unless one reads the present specification. Something not permissible in a determination of patentability. It is only with applicant's teachings, that it would be conceivable that the oxygen concentration could have been affected by nitrogen concentration.

As the Examiner stated, however, Wijarankula does not discuss or suggest a substrate doped with nitrogen and Graef et al does not teach or suggest the epitaxial silicon wafer. Graef doped a CZ silicon wafer with nitrogen but no suggestions were made to dope an epitaxial silicon wafer with nitrogen and no suggestions to nitrogen doping were made to Wijarankula. Since the references must be viewed without the benefit of impermissible hindsight vision afforded by the claimed invention, it would not have been obvious to the one skilled in the art (MPEP2141). Therefore, claims 30 and 31 should be in a condition for allowance.

Tamatsuka discloses gettering capability obtained by controlling oxygen precipitate in the

substrate with nitrogen doping and a resultant epitaxial layer with gettering capability and excellent crystallinity. However, no suggestions to the combination of oxygen and nitrogen concentrations are made although the oxygen and nitrogen concentrations are independently disclosed.

Further, as the Examiner stated, Tamatsuka teaches an oxygen concentration less than 9 x 10^{17} atoms/cm^3 as opposed to the oxygen concentration of 9 x 10^{17} atoms/cm^3 or higher as recited in claim 30 or 31. Since Tamatsuka teaches away from the invention recited in claim 30 or 31 and since Wijarankula does not suggest the nitrogen concentration, it would not have been obvious to the one skilled in the art over Wijarankula in view of Tamatsuka (MPEP 2145).

Claims 30 and 31 recite the limitations of the nitrogen concentrations equal or higher than 1 x 10^{13} atoms/cm^3 and 1 x 10^{14} atoms/cm^3, respectively. As mentioned in the specification (page 5, lines 9-13), if the nitrogen concentration and oxygen concentration are too small, this causes lowered heavy-metal capturing ability due to a decrease of the gettering sites. The range of the nitrogen and oxygen concentrations is so recited that claims 30 and 31 are in a condition for allowance because it would not have been obvioius over Tamatsuka.

Claims 13, 32, and 33

Claim 32 recites that the number of LDPs is less than 20 and the nitrogen concentration and the oxygen concentration have a predetermined correlative relationship.

Graef et al does not teach or suggest the production an apitaxial silicon wafer although it teaches that the proportion of large defects decreases greatly with the increase in the degree of nitrogen doping in silicon wafer prepared by the FZ method. Wijarankula does not teach nitrogen doping to a silicon wafer, there are no suggestions in either references for the combination thereof. Therefore, it would not have been obvious to the one skilled in the art as mentioned above.

Since Tamatsuka does not disclose the number of LDPs and Wijarankula does not teach nitrogen doping in a silicon wafer, claim 32 should be in a condition for allowance because it would not have been obvious to the one skilled in the art.

Claim 33 recites a narrower nitrogen oxygen concentration range than that of claim 32. Since claim 32 is patentable as mentioned above, claim 33 should also be patentable.

Claim 13 is dependent from claim 32 and recites a narrower nitrogen-oxygen concentration range. Since claim 32 is patentable as mentioned above, claim 13 should also be patentable.

Further, the predetermined correlative relationship between the nitrogen concentration and the oxygen concentration such that the epitaxial silicon wafer has sufficient quantity of gettering sites is not disclosed in any one of the cited references. As mentioned in the specification, it may not be easy to control the nitrogen concentration during the CZ method. However, the oxygen concentration can be adjusted by changing the conditions of the CZ method so that it is possible keep the nitrogen and oxygen concentration range on the left side of the first line in figure 2.

As stated later, the number of gettering sites favorable to the quality of the epitaxial wafer may be controlled by the nitrogen and oxygen concentrations. Oxygen concentration adjustment relative to the nitrogen concentration is important. Since none of the cited references, however, disclose or suggest such a relationship, it would not have been obvious to the one skilled in the art at the time of the invention. Claim 33 further limits the nitrogen and oxygen concentrations.

Claims 4, 5, 36 and 37

Claims 4, 5, 36 and 37 recite a method of manufacturing a silicon ingot with the nitrogen and oxygen concentration range falling within an area on or left side of the solid line (1st straight line) in figure 4. Claims 4, 36 and 37 also recites that the nitrogen and oxygen concentrations make a line from the shoulder portion to the tail portion of the silicon single crystal ingot substantially parallel to the first line. Since Tamatsuka or Graef does not disclose a method of manufacturing a silicon ingot with such a nitrogen and oxygen concentration correlative relationship, any one of claims 4, 36 and 37 should be patentable because it would not have been obvious over the cited references.

Claim 36 recites a narrower nitrogen-oxygen concentration range than that of claim 4 and claim 37 recites an even narrower nitrogen-oxygen concentration range than that of claim 36.

Claim 5 incorporates the limitations recited in old claim 4. Since the tail portion tends to be nitrogen rich in the ingot prepared by the CZ method, the nitrogen and oxygen concentrations can be adjusted to be within the range rather easily if the nitrogen concentration at the tail portion is contolled. Thus, claim 5 recites that the nitrogen concentration in the tail portion is set less than 1×10^{13} atoms/cm^3. Since the cited references do not disclose or suggest these features, it would not have been obvious over the cited references and claim 5 should be in a condition for allowance.

Claims 38-41

Claim 38 recites a silicon wafer having the same range of nitrogen and oxygen concentrations (figure 5) as recited in claim 32 as they have a predetermined correlative relationship. Since the predetermined correlative relationship is substantially parallel to the first line, which is not disclosed or suggested in any of the cited references, it would not have been obvious over the cited references as mentioned above.

Since Claim 39 recites a narrower range than that of claim 38, claim 39 should be in a condition for allowance.

Claims 40 and 41 recite smaller ranges than those of claims 38 and 39, respectively (figure 6). Such small ranges are not defined along with the predetermined correlative relationship of the nitrogen and oxygen concentrations in any of the cited references, claims 40 and 41 should be in a condition for allowance.

Claims 8 and 9

Claim 8 recites a silicon ingot prepared by Czochralski or MCZ method, wherein nitrogen concentration of a tail portion of the silicon ingot is in a range of from 1×10^{15} atoms/cm^3 to 3×10^{15} atoms/cm^3 with nitrogen and oxygen concentration relation parallel to the first line in figure 7. Since none of the cited references disclose or suggest the first line in figure 7, it would not have been obvious over the cited references.

Claim 9 is dependent from claim 8 and further recites concentration control method. Therefore, claim 9 should be in a condition for allowance.

Claims 14-16

Claim 14 recites an epitaxial silicon wafer including a silicon wafer substrate with a nitrogen and oxygen concentration range falling in an area on or left side of the 1st straight line and on or right side of the third straight line in figure 9. The nitrogen and oxygen concentration range, thus, indicates a predetermined correlative relationship between nitrogen and oxygen concentrations, which are not disclosed or suggested by any of the cited references. Since the nitrogen and oxygen concentration range shows a unique correlative relationship, it would not have been obvious over the cited references.

Claim 15 is dependent from claim 14. Claim 15 recites a narrower concentration range band than that of claim 14 such that the correlative relationship, which is not disclosed or suggested in any of the cited references, becomes clearer than claim 14. Thus, it would not have been obvious over the cited references.

Claim 16 is dependent from claim 14. Claim 15 recites a narrower concentration range band than that of claim 14 such that the correlative relationship, which is not disclosed or suggested in any of the cited references, becomes clearer than claim 14. The band of claim 16 is higher in the nitrogen concentration than that of claim 15. Thus, it would not have been obvious over the cited references.

Claims 17 and 18

Claim 17 recites a group of epitaxial silicon wafers including respective silicon wafer substrates with the nitrogen and oxygen concentration range falling in an area between the first and the fourth straight lines in figure 10. The silicon ingot has varying concentrations of nitrogen and oxygen along the pulling direction and silicon wafers utilized as substrates in the epitaxial growth are sliced one wafer after another along the pulling direction. Therefore,a group of silicon wafers sliced from one silicon ingot having the nitrogen and oxygen concentration range falling in an area indicated in figure 10 may have a series of nitrogen and oxygen concentrations parallel to or along the first or fourth straight line. Since such group is not disclosed or suggested in any of the cited references, it would not have been obvious over the cited references.

Claim 18 recites a group of epitaxial silicon wafers including respective silicon wafer substrates with nitrogen and oxygen concentration range falling in an area between the second and the third straight lines in figure 10. As mentioned above, since none of the cited references disclose or suggest such a group of silicon wafers, it would not have been obvious over the cited references.

Claims 22 and 25-29

Claims 22 and 25-29 recite methods of manufacturing the epitaxial silicon wafer with substrates defined in claims 4, 8, 14, 15 and 17, respectively. Each method comprises grinding silicon wafer substrate(s), and performing epitaxial growth on the groud silicon wafer(s)utilizing trichlorosilane. Since claims 4, 8, 14, 15 and 17 recite novel and nonobvious product over the cited references, the methods of manufacture thereof should be patentable.

Claims 42 and 43

When nitrogen is doped into a silicon ingot, the concentration of the nitrogen gradually and continuously increases from the shoulder portion to the tail portion of the silicon ingot (this is called "segregation").

The present invention utilizes the segregation. More specifically, by setting the amount of doping of nitrogen so that the nitrogen concentration in the tail portion of the silicon ingot is less than the allowable upper limit (3×10^{15} atoms/cm^3), the nitrogen concentration in the entire silicon ingot can be less than 3×10^{15} atoms/cm^3. Further, by suitably controlling the oxygen concentration in the silicon ingot in accordance with the change in the nitrogen concentration in the silicon ingot, the entire straight body portion of the silicon ingot can be used as a silicon wafer substrate for an epitaxial silicon wafer. Thus, the device production yield can be improved (refer to page 6. line 16 through page 7, line 8 of the specification, and Figure 2).

Neither Graef et al. nor Tamatsuka (Wajarankula does not, of course) teach or suggest the segregation of nitrogen. Further, these citations do not teach or suggest the technique of controlling the nitrogen concentration in the entire silicon ingot by setting the nitrogen concentration in a specific portion (the tail portion) of the silicon ingot to be less than the allowable upper limit (3×10^{15} atoms/cm^3. Therefore, we believe that invention recited in claims 42 and 43 is allowable over these citations.

Applicant hereby requests reconsideration and reexamination thereof.

With the above amendments and remarks, this application is considered ready for allowance and Applicant earnestly solicits an early notice of same. Should the Examiner be of the opinion that a telephone conference would expedite prosecution of the subject application, he is respectfully requested to call the undersigned at the below-listed number.

Respectfully submitted,

WELSH & KATZ, LTD.

Gerald T. Shekleton
Registration No. 27,466

Dated: September 9, 2005

WELSH & KATZ, LTD.
120 S. Riverside Plaza, 22nd Floor
Chicago, IL 60606-3913
Telephone: 312/655-1500
Facsimile: 312/655-1501